SHARP

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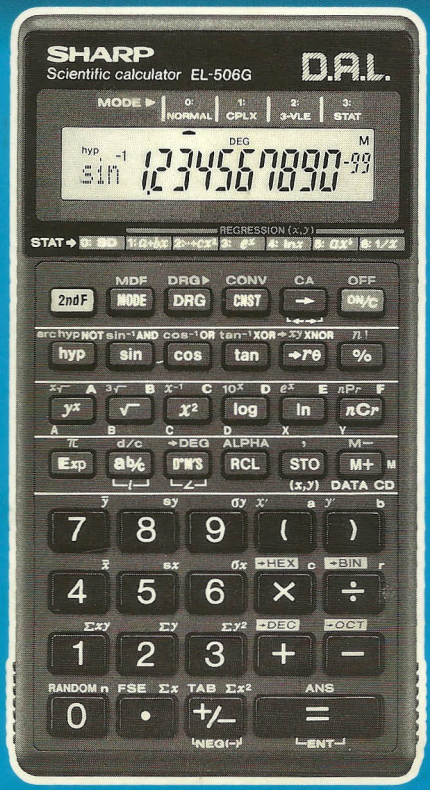
SHARP®

EL-506G
SCIENTIFIC CALCULATOR

OWNER'S MANUAL AND SOLUTIONS HANDBOOK

FUNCTION DISPLAY

D.A.L.
DIRECT ALGEBRAIC LOGIC



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The Sharp EL-506G Scientific Calculator

Owner's Manual and Solutions Handbook

Marcos Aparecido de Souza
1996.

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When Abnormal Conditions Cause a Malfunction

If the calculator is subjected to large external noises or severe shock while in use, all the keys including [ON/C] might sometimes become inoperative. When this occurs, press the Reset Switch <RESET> on the back of the calculator. As a result, all the contents stored in memory and storage areas are cleared.

◆Press the Reset Switch only in the following cases:

- To exchange the batteries
- To clear all stored contents
- When all key functions are inoperative due to a malfunction

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Chapter 1:
Getting Started

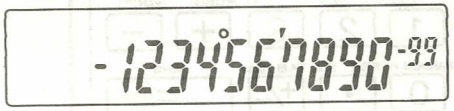
This chapter introduces your Sharp scientific calculator. The calculator's keys and display screen are described, along with number entry, correcting mistakes, and the calculator's display formats and memories. The four operating modes of the calculator are also introduced.

The Calculator's Display

The display of the Calculator consists of a numeric display, status indicators, and a three-character dot matrix guidance display (Function Display)

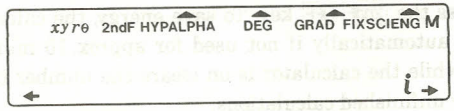
This calculator uses D.A.L.(Direct Algebraic Logic)method for arithmetic operation. D.A.L.is a method in which an expression is entered in the written order.
For example, to calculate sin 30 + cos 45, press [sin] 30 [+] [cos] 45 [=].
You can calculate a complicated expression easily using this method.

The numeric display



The dot matrix guidance display (Function Display)

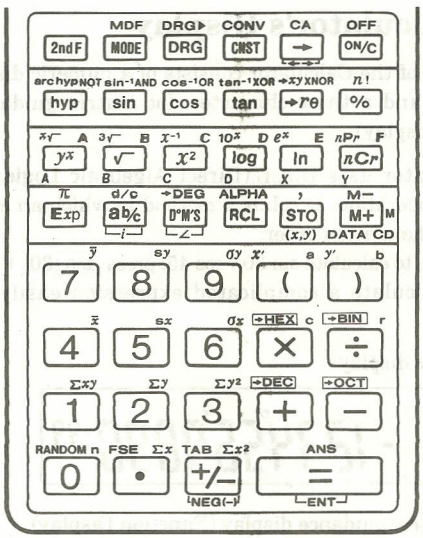
The display status indicators



You will learn the meaning of each of these displays and indicators as you read through this manual.

The Calculator's Keys

The lower rows of the calculator's keyboard contain the digit keys, and simple arithmetic operation keys. The upper rows contain the OFF ON/C key, arithmetic function keys, memory keys, and keys that select display formats and operating modes.


MDF DRG▸ CONV CA OFF
2ndF MODE DRG CNST → ON/C
archyp NOT sin-1 AND cos-1 OR tan-1 XOR →xy XNOR n!
hyp sin cos tan →r'θ %
x√ A 3√ B x-1 C 10x D ex E nPr F
yx √ x2 log ln nCr
A B C D X Y
π d/c →DEG ALPHA , M−
Exp ab/c D°M'S RCL STO M+ M
(x,y) DATA CD
x̄ sy σy x' a y' b
7 8 9 ( )
x̄ sx σx →HEX c →BIN r
4 5 6 × ÷
Σxy Σy Σy2 →DEC →OCT
1 2 3 + −
RANDOM n FSE Σx TAB Σx2 ANS
0 • +/− =
NEG(−) ENT

Turning the Calculator On and Off

Turn your calculator on by pressing the ON/C key. To turn the calculator off, press the 2ndF OFF key. To save energy, the calculator turns itself off automatically if not used for approx. 10 minutes. Pressing ON/C while the calculator is on clears the number in the display and any unfinished calculations.

Getting a Fresh Start

Until you are familiar with the calculator's various operating modes and display formats, it's good idea to start by using the calculator's most basic settings. Do this as follows:

- Press the MODE key. The prompt **?0-3** appears at the left end of the display.
- Select NORMAL mode by pressing 0.
- Press the 2ndF FSE key repeatedly until none of the format indicators (**FIX, SCI, ENG**) appear at the top of the display. This puts the calculator in floating point format.

"▲" pointing to NORMAL tells you the calculator is set to NORMAL mode, decimal base, and floating point format. However, one of the three angular unit indicators (**DEG, RAD, GRAD**) will always be present. (See Chapter 2 for details.) Unless otherwise noted, the rest of this chapter assumes that your calculator is in NORMAL mode, using decimal base and floating point format.

Entering Numbers

Enter numbers using the digit keys 0 through 9, the decimal point key ·, and the change-sign key +/−. These keys are called the number entry keys.

Example: Enter the number 123.4.
Press: 1 2 3 · 4
Result: 123.4

Throughout the rest of this manual, numbers given in examples are shown normally, for example, 123.4 instead of 1 2 3 · 4.

CORRECTING ENTRIES

You can delete individual digits by using the backspace key →| before pressing a function key. Press →| once for each digit you want to remove. The →| key no longer operates after a function key has been pressed.

Example: Enter the number 42060.

Press: 42070. A mistake.

Press → → 60 The remedy.

Result: 42060.

You can also delete an entire entry by pressing the ON/C key before pressing a function key. The ON/C key no longer operates after a function key has been pressed.

Example: Enter the number 623.61.

Press: 523.61 A mistake.

In this case, it's quicker to use the ON/C key than to press → five times.

Press: ON/C The display is cleared.

Press: 623.61

Result: 623.61

Pressing ON/C twice causes an entire entry to be deleted.

Example: Clear the display 2+3.

Press: 2 + 3 ON/C

Result: + – ("3" is cleared)

Press: ON/C

Result: 0. (the entire entry is cleared)

USING THE SECOND FUNCTION KEY

The second function of a key is printed above it. You can use a key's second function by pressing the 2ndF key and then the function key.

When you press 2ndF, the **2ndF** indicator appears in the upper portion of the display. This indicator tells you that you will be selecting the second function of the next key you press. If you press 2ndF by mistake, simply press 2ndF again to remove the **2ndF** indicator.

THE CHANGE SIGN KEY +/–

The +/– key changes the sign of the number in the display.

Example: Enter – 38.

Press: +/– 38 (or 38 +/–)

Result: – 38.

Formatting the Display

The calculator can display numbers in four formats: **floating point, fixed point, scientific,** and **engineering.** Display formats are selected by pressing the 2ndF FSE key. Pressing 2ndF FSE repeatedly moves through the display formats in the following order: **floating point, fixed point (FIX), scientific (SCI),** and **engineering (ENG).**

FLOATING POINT DISPLAY FORMAT

The floating point format displays numbers in decimal form, using up to 10 digits. Any trailing zeros are truncated. The floating point display format is indicated by the *absence* of a format indicator (**FIX, ENG,** or **SCI**).

DISPLAYS WITH FIXED DECIMAL PLACES

The fixed point, scientific, and engineering formats use a fixed number of decimal places to display numbers. Select the number of decimal places displayed by using the 2ndF TAB function, as follows:

- Press 2ndF TAB key, and enter the number of decimal places desired.

FIXED POINT DISPLAY FORMAT

Select the fixed point format by pressing 2ndF FSE until the indicator **FIX** appears in the display.

Example: Enter 3.23176 in the fixed point format, with 4 decimal places.

Press:	2ndF TAB 4	Display 4 decimal places.
	3.23176 =	
Result:	3.2318	The number is rounded to 4 decimal places.

SCIENTIFIC DISPLAY FORMAT

Select the scientific format by pressing 2ndF FSE until the **SCI** indicator appears.

Example: Enter the number 5.113×10^{-7} using the scientific format.

Press:	2ndF TAB 3	Display 3 decimal places.
	5.113 Exp +/- 6	Oops! Wrong exponent!
	07	07 replaces 06.
Result:	5.113^{-07}	

ENGINEERING DISPLAY FORMAT

Select engineering format by pressing 2ndF FSE until the **ENG** indicator appears.

Example: Enter the number 5.113×10^{8} using the engineering format.

Press:	2ndF TAB 3	Display 3 decimal places.
	5.113 Exp 8 =	
Result:	511.300^{06}	The exponent is changed to a multiple of three.

When the result exceeds the calculation range due to rounding, the specified number of decimal places is ignored.

The FSE and TAB keys are not available while any expression is displayed. Press the ON/C key twice or complete the operation using the = key before entering FSE or TAB key.

Memories

Each of the Sharp calculator's operating modes has a number of memories available. The memories available in NORMAL mode are the six **temporary memories** (**A** through **D**, **X**, and **Y**), the **independent memory** (**M**) and the **last answer memory** (**ANS**). The independent memory (M) can be used in NORMAL and CPLX mode. The temporary memories A through D, X, and Y can be used in NORMAL mode. When the mode is switched to another mode, these temporary memories are cleared.
Memories available in other modes are described in the chapters discussing those modes.

THE TEMPORARY MEMORIES A THROUGH D, X, AND Y

Store a number from the display into a temporary memory as follows:

- Press STO. The **ALPHA** indicator appears.
- Press one of A through D, X, and Y keys for the memory you want to store. An indicator showing the memory you have chosen appears in the left portion of the display. For example, if you store to memory A, the indicator ⇒ **A** appears.

Recall numbers from temporary memories in a similar way:

- Press RCL. The **ALPHA** indicator appears.
- Press one of A through D, X, and Y keys for the memory you want to recall. An indicator showing which memory you have recalled appears in the left portion of the display.
- You can also recall the numbers by pressing 2ndF ALPHA A through D, X, and Y =.

If you press STO or RCL by mistake, you can cancel by pressing the same key again.

Example: Store the numbers 2.04, 7984, and 10.388 in memories A, B, and C respectively.

Press:	2.04 STO	**ALPHA** appears.
	A	The indicator ⇒ **A** appears.

	7984 [STO]	ALPHA appears.
	B	⇒ **B** appears.
	10.388 [STO]	ALPHA appears.
	C	⇒ **C** appears.

Now use [RCL] to check the contents of the memories.

Press:	[RCL] A	
Result:	2.04	The contents of A.
Press:	[RCL] B	
Result:	7984.	The contents of B.
Press:	[RCL] C	
Result:	10.388	The contents of C.

Example: Calculate the area of a circle (πr^2) with 3 cm of radius. (Use a temporary memory A for r.)

Press:	3 [STO] [A]	The indicator ⇒ A appears at the right.
Press:	[2ndF] [π]	
	[2ndF] [ALPHA] [A] [x^2]	"(∗) 9." appears.* (Multiplication is indicated by "∗".)
	[=]	
Result:	28.27433388	

∗The "(×)" notation indicates that the multiplication symbol "×" is omitted between π and A.

When you use functions shown below, the value stored in X or Y memory is changed by these functions.

- Random number ····· Y memory
- $\rightarrow r\theta$, $\rightarrow xy$ ····· X and Y memories

These functions use automatically X and Y memories to store the calculation result.

THE INDEPENDENT MEMORY [M]

Store numbers in the independent memory by pressing [STO] [M], and recall them by pressing [RCL] [M] or [2ndF] [ALPHA] [M] [=]. You can also add to the number stored in the independent memory by using the **memory add** key [M+] and subtract form the number by using the **memory subtract** key [2ndF] [M−].

When a number is stored in the independent memory, the symbol **M** appears in the upper right corner of the display, and remains until the memory is cleared by storing 0 in it.

Example: Store 13 in the independent memory, verify that it has been stored, then add 14 to it.

Press:	13 [STO] [M]	The indicator **M** appears at the top right of the display, and the indicator ⇒ **M** appears.
	[ON/C]	The ⇒ **M** indicator disappears, but **M** remains.
	[RCL] [M]	To verify storage.
Result:	M 13.	
Press:	14 [M+]	Add 14 to the contents of the memory.
	[RCL] [M]	
Result:	M 27.	The sum of 13 and 14 is tored in the independent memory.

Now clear the memory by storing 0 in it.

Press:	0 [STO] [M]	**M** disappears. ⇒ **M** appears, but disappears when any other key is pressed.

THE LAST ANSWER MEMORY

In NORMAL mode and STAT mode (except quadratic regression), the calculator automatically stores the number in the display whenever [=] or [M+] is pressed. You can recall this number, called the **last answer**, by pressing [2ndF] [ANS].

You should keep the following points in mind when using the calculator's memories:

- When you store a number in a memory, you erase any number that was already there.
- A memory is cleared by storing the value 0 in it.
- Recalling from a memory does not affect its contents.
- The contents of the memories are retained when the calculator is turned off or shuts itself off.
- All memories except the independent memory are cleared when you change operating modes.

Example: Divide 25 by 4, then divide 100 by the result.

Press:	25 [÷] 4 [=]	
Result:	6.25	This number is stored in the last answer memory.
	100 [÷] [2ndF] [ANS]	
Result:	/ 6.25	The last answer is recalled to the display.
	[=]	
Result:	16.	

Operating Modes

The calculator has four powerful operating modes that greatly expand the range of calculations you can perform.

0: Normal mode. This is the mode most commonly used for everyday calculations. (See Chapter 2.)

1: Complex (CPLX) mode. This mode enables you to perform computations with complex numbers.(See Chapter 3.)

2: Three-variable (3-VLE) mode. This mode enables you to solve up to three simultaneous linear equations with three unknowns. (See Chapter 4.)

3: Statistics (STAT) mode. This mode allows you to perform a wide variety of statistical calculations, including six types of regression analysis. (See Chapter 5.)

You can change operating modes as follows:

- Press [MODE]. The prompt **?0-3** appears at the left end of the display.
- Press the number of the mode you want to enter:
  - 0 for **NORMAL** mode
  - 1 for **CPLX** mode
  - 2 for **3-VLE** mode
  - 3 for **STAT** mode

Pressing [MODE] twice leaves you in the mode you started with.

The calculator retains its operating mode when it is turned off or shuts itself off.

Chapter 2:
Calculating in Normal Mode

This chapter tells you how to use your Sharp calculator in NORMAL mode, describes the available mathematical function keys and explains how calculations are ordered, and how to do calculations in binary, octal, and hexadecimal numbering bases.
Before proceeding, check to see that your calculator is in NORMAL mode, with decimal base and floating point display.

Basic Arithmetic

Basic arithmetic calculations on the calculator use the arithmetic operator keys, ([+], [−], [×], [÷]) and the [=] key. You enter simple calculations from left to right, just as they appear on the written page.

Example: Calculate 5 + 3 × 4 + 2.
Press: 5 [+] 3 [×] 4 [+] 2 [=]
Result: 19.

Example: Calculate 981.8 × 4 ÷ 5 − 6.
Press: 981.8 [×] 4 [÷] (Division is indicated by "/".)
5 [−] 6 [=]
Result: 779.44

CORRECTING THE WRONG OPERATOR

If you press the wrong arithmetic operation key, enter the correct operation by pressing the correct key before any other keys are pressed.

Example: Calculate 20.25 × 15.
Press: 20.25 [÷] A mistake.
[×] 15 [=] The remedy.
Result: 303.75

Ordering the Calculations

When you enter a calculation that consists of several operations, the calculator assigns each operation a priority as specified by the rules of algebra.

Priority	Operation
1.	π, recall of memory contents
2.	∠
3.	Functions that require a number before (%, x^{-1}, x^2, n!, etc.)
4.	y^x, $\sqrt[x]{y}$
5.	Multiplication without × operator before a memory (2A, etc.)
6.	Functions that require a number after (sin, cos, etc.)
7.	Multiplication without × operator before a function (2sin30, etc.)
8.	nCr, nPr
9.	×, ÷
10.	+, −
11.	AND
12.	OR, XOR, XNOR
13.	Calculation end operation such as =, M+, M−, ⇒ M, ▶D, ▶R, ▶G, →BIN, →OCT, →HEX, →DEC, x', y', DATA, CD, $\rightarrow r\theta$, and $\rightarrow xy$

The calculator then performs the operations in the order of priority. If an expression contains two or more operations having the same priority, the calculator performs these operations in the order they were entered.

Example: By the rules of algebra, 3 × 4 + 2 × 6 is calculated in the following order.
(3 × 4) + (2 × 6) = 24
The calculator calculates in this same order.
Press: 3 [×] 4 [+] 2 [×] 6 [=]
Result: 24.

PARENTHESES

You can override the calculator's default calculation priorities by using parentheses. Expressions inside parentheses are always computed first. Parentheses are entered exactly as they would appear in a written equation.

Open parentheses are indicated by the "("indicator at the left end of the display. The "(" indicator appears when the first parenthesis is opened and disappears when the next operator or function is entered.

Example: Calculate $(4 + 8) \times (7 - 3) \div 2$.

Without parentheses, the calculator would do this calculation in the order:

$$4 + (8 \times 7) - (3 \div 2) = 58.5$$

By inserting parentheses, you tell calculator to perform the operations inside the parentheses first.

Press: [(] 4 [+] 8 [)] [×] [(] 7 [−] 3 [)] [÷] 2 [=]

Result: 24.

When the [=] or [M+] key is pressed, the calculator automatically closes any open parentheses and calculates the final result.

PENDING OPERATIONS

An operation is said to be *pending* if it is left uncompleted while the calculator performs another operation having a higher priority.

The calculator allows up to 16 pending operations and stores up to 6 numbers (※). More than these results in an error.

※ The calculator stores up to 6 numbers in NORMAL mode, up to 4 numbers in CPLX mode, 1 number in 3-VLE mode, and up to 4 numbers in STAT mode. For quadratic regression in STAT mode which uses a, b, and c, however, the calculator stores up to 8 operations and 1 number.

CONSTANT CALCULATIONS

The calculator enables you to repeat a basic operation (+, −, ×, and ÷) with a constant.

· If you enter a number, press an arithmetic operator key, and then press [→] . The calculator will use the constant and the operator in further calculation.

Example: Calculate 68×25 and 68×40.

Press: 68 [×] [→] The indicator "x ∗ ? " appears.

25 [=]

Result: 1700.

Press: 40 [=]

Result: 2720.

If you press [→] again, the constant moves to the next position of the operator.

Example: Calculate 48−23 and 14−23.

Press: [ON/C] 23 [−] [→] [→] The indicator " ? − x" appears. x is just after −.

48 [=]

Result: 25.

Press: 14 [=]

Result: − 9.

· x in the display means a constant, and ?, an entered value.

· A function requiring two numbers such as y^x and nCr or an expression including an arithmetic operator (such as 23 + 4) cannot be used as an entered value.

· To cancel constant calculation, press [ON/C]

THE MODIFY KEY

The calculator stores calculated results in an unformatted form with up to twelve digits, plus two additional digits for an exponent (if any). The calculator uses this number in further calculations, eliminating common round-off errors.

Pressing the [2ndF] [MDF] key replaces the calculator's unformatted internal version of a number with the number in the display.

Example: At a fixed accuracy of 2 decimal places, compare the calculations of $1 \div 3 = 0.33$ and $1 \div 3 \times 3 = 1.00$.

Press:	[2ndF] [FSE]	Until **FIX** appears.
	[2ndF] [TAB] 2	Display 2 decimal places.
Press:	1 [÷] 3 [=]	The display shows 0.33, but uses 0.33333333333 in later calculations.
	[×] 3 [=]	
Result:	1.00	Not 0.99.

Recalculate $1 \div 3 \times 3$, and use the modify key to replace the calculated value of 1 / 3 with 0.33.

Press:	1 [÷] 3 [=]	
	[2ndF] [MDF] [×] 3 [=]	The calculator now uses 0.33 in any later calculations.
Result:	0.99	

Now change to floating point format.

Press:	[2ndF] [FSE]	Until no display format indicator appears.
Result:	0.99	

Function Keys

The calculator's function keys enable you to perform a wide variety of mathematical operations.

RECIPROCALS

Calculate the reciprocal of the number in the display by pressing [2ndF] [x^{-1}]

Example: Calculate the reciprocal of 974.87

Press: [ON/C] 974.87 [2ndF] [x^{-1}]

Result: 0.001025777

PERCENTAGES

Pressing the [%] key converts the number in the display into a percentage. This number can then be used in calculations.

The [%] key also simplifies arithmetic involving percentages as shown in examples below.

Example: Increase 38 by 15%.
Press: 38 [+] 15 [%] [=]
Result: 43.7

Example: Calculate 47% of 219.
Press: 219 [×] 47 [%] [=]
Result: 102.93

POWER FUNCTIONS

The [x^2] key calculates the square of the number in the display.

Example: Calculate the square of 15.
Press: [ON/C] 15 [x^2]
Result: 225.

The [y^x] key raises a number y to the power x. Use it as follows:

Example: Calculate 7 to the 4th power.
Press: [ON/C] 7 [y^x] 4 [=]
Result: 2401.

The [$\sqrt{\ }$] key calculates the square root of the number x.

Example: Calculate the square root of 27.
Press: [ON/C] [$\sqrt{\ }$] 27 [=]
Result: 5.196152423

The [2ndF] [$\sqrt[3]{\ }$] key calculates the cube root of the number x.

Example: Find the cube root of 1234.
Press: [ON/C] [2ndF] [$\sqrt[3]{\ }$] 1234 [=]
Result: 10.72601467

The [2ndF] [$\sqrt[x]{\ }$] key calculates the xth root of the number y.

Example: Find the 5th root of 243.

Press: [ON/C] 5 [2ndF] [$\sqrt[x]{}$] 243 [=]

Result: 3.

The [2ndF] [n!] key calculates the factorial of the number in the display.

Example: Calculate 14!

Press: [ON/C] 14 [2ndF] [n!]

Result: 8.71782912^{10}

LOGARITHMIC/EXPONENTIAL FUNCTIONS

The common logarithm key [log] displays the base 10 logarithm of the number x.

Example: Calculate the common logarithm of 31.62.

Press: [ON/C] [log] 31.62 [=]

Result: 1.499961866

The natural logarithm key [ln] displays the base e logarithm of the number x.

Example: Calculate the natural logarithm of 31.62.

Press: [ON/C] [ln] 31.62 [=]

Result: 3.453789832

The [2ndF] [10^x] key raises 10 to the power of the number x.

Example: Calculate $10^{4.7}$

Press: [ON/C] [2ndF] [10^x] 4.7 [=]

Result: 50118.72336

The [2ndF] [e^x] key raises e to the power of the number x.

Example: Calculate e^1.

Press: [ON/C] [2ndF] [e^x] 1 [=]

Result: 2.718281828 This is the base number e.

TRIGONOMETRIC FUNCTIONS

Your Sharp calculator enables you to perform trigonometric calculations using any of three units of angular measure: degrees, radians, and grads. Select the angular units you want to use by pressing the [DRG] key. The unit selected is shown by an indicator (**DEG, RAD**, or **GRAD**) at the top of the display.

SINES, COSINES, AND TANGENTS

The [sin], [cos], and [tan] keys calculate the sine, cosine, and tangent of the value that is entered just after.

Example: Calculate sin 30° and cos 0.8775 radians.

Press: [DRG] Until **DEG** appears.

[ON/C] [sin] 30 [=]

Result: 0.5

Press: [DRG] Until **RAD** appears.

[ON/C] [cos] .8775 [=]

Result: 0.639075998

The [2ndF] [$\sin^{-1}$], [2ndF] [$\cos^{-1}$], and [2ndF] [$\tan^{-1}$] keys calculate the arcsine ($\sin^{-1}$), arccosine ($\cos^{-1}$), and arctangent ($\tan^{-1}$) of the number that is entered just after.

Example: Calculate $\sin^{-1}$ 0.76 in degrees.

Press: [DRG] Until **DEG** appears.

[ON/C] [2ndF] [$\sin^{-1}$] .76 [=]

Result: 49.46419789

The calculation result can be used as the first entered number.

Example: calculate sin (25° + 5°).

Press: [DRG] Until **DEG** appears.

25 [+] 5 [=]

Result: 30.

Press: [sin] [=]

Result: 0.5 sin 30°

THE PI KEY

Pressing [2ndF] [π] enters the value of pi. Only the first 10 digits are displayed, but the calculator uses 12 digits in calculations.

Example: Recall pi.

Press: [ON/C] [2ndF] [π] [=]

Result: 3.141592654

CONVERTING AMONG ANGULAR UNITS

The calculator allows you to easily convert angles from one angular unit to another. Do this as follows:

- Press [DRG] repeatedly until the angular unit you are converting *from* is indicated in the display.
- Enter the angle your want to convert.
- Press [2ndF] [DRG▸] repeatedly until the calculator indicates the angular unit you are converting *to*. (Note that the [DRG] key is not the same as the [2ndF] [DRG▸] key). The calculator automatically converts the angle to the new units.

Example: Convert 90 degrees into radians and grads.

Press: [DRG] Until **DEG** appears.

90

Convert this in radians:

Press: [2ndF] [DRG▸] ▶ **R** and **RAD** appear.

Result: ▶ **R** 1.570796327

Now convert to grads:

Press: [2ndF] [DRG▸] ▶**G** and **GRAD** appear.

Result: ▶**G** 100.

A MATTER OF DEGREE

The calculator can also perform calculations on numbers in *sexagesimal* (base 60) from. Sexagesimal calculations are available in NORMAL and STAT modes.

Sexagesimal form represents angles and time using the form DD° MM′ SS.SS, Where DD represents the number of degrees or hours, MM represents number of minutes, and SS.SS represents the number of seconds. Enter angles in sexagesimal form using the [D°M'S] key.

If you make a mistake while entering a number, just type in the correct number. The last digits entered will replace the previous ones.

Example: Enter 24 degrees, 34 minutes, 30.27 seconds.

Press: 24 [D°M'S]
34 [D°M'S]
30 [D°M'S]
27

Result: 24° 34′ 30.27

CHANGING FORMS

You can easily convert numbers from sexagesimal to decimal form, or vice versa, using the [D°M'S] and [2ndF] [→DEG] keys. Convert angles from sexagesimal to decimal form by pressing [2ndF] [→DEG] .

Example: Convert 12° 39′ 18″ to decimal form.

Press: [ON/C] 12 [D°M'S] 39 [D°M'S] 18
[2ndF] [→DEG]

Result: 12.655

Convert angles from decimal to sexagesimal form using the [D°M'S] key. The number in the display must contain a decimal point.

Example: Convert 123.432° into sexagesimal form.

Press: 123.432 [D°M'S]

Result: 123° 25′ 55.20

TIME

The calculator's sexagesimal form can also be used to express time in hours, minutes, and seconds.

Example: Add 8 hours, 21 minutes, 42 seconds; 15 hours, 3 minutes, 39.5 seconds; and 1 hour, 45 minutes.

Press: 8 [D°M'S] 21 [D°M'S] 42 [+]
15 [D°M'S] 3 [D°M'S] 39 [D°M'S] 50 [+]
1 [D°M'S] 45 [=]

Result: 25° 10′ 21.50 — 25 hours, 10 minutes, and 21.5 seconds.

CALCULATIONS IN SEXAGESIMAL AND DECIMAL

The calculator allows you to add, subtract, multiply and divide sexagesimal and decimal numbers at the same time. The following table shows the resulting forms of arithmetic operations involving both decimal and sexagesimal numbers.

Addition/ Subtraction	sexagesimal (+ , −) sexagesimal = sexagesimal
	sexagesimal (+ , −) decimal = decimal
	decimal (+ , −) sexagesimal = decimal
Multiplication/ Division	sexagesimal (× , ÷) sexagesimal = decimal
	sexagesimal (× , ÷) decimal = sexagesimal
	decimal × sexagesimal = sexagesimal
	decimal ÷ sexagesimal = decimal

Example: Add 5° 45′ 30 to 16.5 and to 31° 19.

Press: 5 [D°M'S] 45 [D°M'S] 30 [+] [→] 16.5 [=]

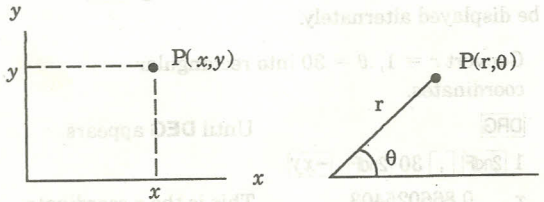
Result: x + ? 22.25833333

Press: 31 [D°M'S] 19 [=]

Result: x + ? 37° 04′ 30.00

POLAR AND RECTANGULAR COORDINATES

The calculator enables you to convert between rectangular and polar coordinates quickly and easily. When using these conversions, make sure the calculator is set for the angular units (**DEG**, **RAD**, or **GRAD**) you are using.



Rectangular Coordinates — Polar Coordinates

CONVERTING FROM RECTANGULAR TO POLAR

Convert from rectangular coordinates to polar coordinates as follows:

- Enter the x coordinate, [2ndF] [,] , and y in this order and then press [→rθ], and r in polar coordinate appears.
- If you press [←→], θ appears. Pressing [←→] causes r and θ to be displayed alternately.

Example: Convert (3, 4) into polar coordinates.

Press: [DRG] Until **DEG** appears.
3 [2ndF] [,] 4 [→rθ]

Result: r 5.→ This is the radius.

Press: [←→]

Result: ←θ 53.13010235 This is the angle θ in decimal degrees.

Press: [←→]

Result: r 5.→ This is also the radius.

CONVERTING FROM POLAR TO RECTANGULAR

Convert from polar coordinates to rectangular coordinates as follows:

- Enter the r coordinate, [2ndF] [,], and θ in this order and then press [2ndF] [→xy], and x coordinate appears.
- If you press [←→], y coordinate appears. Pressing [←→] causes x and y to be displayed alternately.

Example: Convert $r = 1$, $\theta = 30$ into rectangular coordinates.

Press:	[DRG]	Until **DEG** appears.
	1 [2ndF] [,] 30 [2ndF] [→xy]	
Result:	x 0.866025403→	This is the x coordinate.
Press:	[←→]	
Result:	←y 0.5	This is the y coordinate.
Press:	[←→]	
Result:	x 0.866025403→	This is also the x coordinate.

The calculation results of →$r\theta$ or →xy are automatically stored in X and Y memories.

Value of r or x: X memory

Value of θ or y: Y memory

Values stored in the memories X and Y by memory calculation are cleared by the coordinate conversion as a result.

HYPERBOLIC FUNCTIONS AND THEIR INVERSES

Example: Calculate the sinh of π.

Press: [ON/C] [hyp] [sin] [2ndF] [π] [=]

Result: 11.54873936

Example: Calculate the $\cosh^{-1}$ of 5.

Press: [ON/C] [2ndF] [archyp] [cos] 5 [=]

Result: 2.29243167

COMBINATIONS AND PERMUTATIONS

COMBINATIONS

The combinations key [nCr] calculates the number of possible combinations of r items that can be selected out of a set containing n items.

Example: How many combinations of 3 items can you select out of a set of 15 items?

Press: 15 [nCr] 3 [=]

Result: 455.

PERMUTATIONS

The permutations key [2ndF] [nPr] calculates the number of *possible orderings* of r items taken from a set of n items.

Example: How many permutations of 3 items can you select out of a set of 15 items?

Press: 15 [2ndF] [nPr] 3 [=]

Result: 2730.

RANDOM NUMBERS

Pressing the [2ndF] [RANDOM] key displays a three decimal place random number between 0.000 and 0.999.

- When a random number is generated, the temporary memory Y is used. (pseudo-random number sequence)
- To generate a new random number sequence, press [ON/C] [STO] [Y] to clear the temporary memory Y.

Example: Generate a random number.

Press: [2ndF] [RANDOM]

Result: 0.659 The number you generate will of course be different.

You can use random numbers in expressions just as any other number.

Using Physical Constants

Your calculator contains the values of 32 commonly used physical constants (see Appendix A) which are available only in decimal base NORMAL mode.

Call up a constant by entering a constant number after pressing [CNST].

- A constant is displayed conforming to display format and floating point designation.
- You can call up physical constants in NORMAL mode except in binary, octal, or hexadecimal notation, 3-VLE mode, and STAT mode.

Example: Call up g, the acceleration of gravity (number 3 in the table in Appendix A).

Press: [CNST] 03

Result: 9.80665

The physical constants are inserted into a calculation just as any other number.

Example: Multiply the mass of an electron by 60. (The electron mass is number 4 in the table.)

Press: 60 [×] [CNST] 04 [=]

Result: 5.46563382^{-29}

Using Metric Conversions

The calculator has a built-in metric conversion feature (See Appendix A) that is available only in decimal base NORMAL mode.

Press [2ndF] [CONV] and enter a constant number.

- You can use metric conversion in NORMAL except in binary, octal, or hexadecimal notation, 3-VLE, and STAT modes.

Example: Convert 535 miles into kilometers.

Press: 535 [2ndF] [CONV] 07

Result: 860.99904 In kilometers.

As with physical constants, metric conversions can be performed while entering an expression.

Example: Convert 42.7 pounds into kilograms, add 71.6, and multiply by 3.

Press: 3 [×] [(] 42.7 [2ndF] [CONV] 15 [+] 71.6 [=]

Result: 272.9051826

Calculating with Other Bases

The calculator can add, subtract, multiply, and divide binary (base 2), octal (base 8), and hexadecimal (base 16) numbers. Other mathematical functions are not available.

Select the numbers base you want to use with the [2ndF] [→BIN], [2ndF] [→OCT], [2ndF] [→HEX], or [2ndF] [→DEC] keys. The **BIN**, **OCT**, and **HEX** indicators show you which base you are using. (If none of the indicators appear in the display, you are in decimal base.)

BINARY, OCTAL, AND HEXADECIMAL BASE CALCULATIONS

Example: Add the binary number 1 and 1.

Press: [ON/C] [2ndF] [→BIN] → **BIN** appears.

1 [+] 1 [=]

Result: $10._b$

Example: Multiply the octal numbers 5 and 5.

Press: [ON/C] [2ndF] [→OCT] → **OCT** appears.

5 [×] 5 [=]

Result: 31.o

Example: Multiply the hexadecimal number A1 and 4F.

Press: [ON/C] [2ndF] [→HEX] → **HEX** appears.

A1 [×] 4F [=]

Result: 31AF.H

Take care when reading the display to distinguish between the digit 6 and the letter b. They appear similar in the display.

NEGATIVES AND COMPLEMENTS

In binary, octal and hexadecimal bases, pressing the [NEG(-)] key gives the complement of the number that is entered just after.

Example: Calculate the ten-bit complement of the binary number 10110.

Press: [ON/C] [2ndF] [→BIN]

[NEG(-)] 10110 [=]

Result: 1111101010.b

CONVERTING BETWEEN BASES

Whey you switch to a new base, the calculator attempts to convert the number in the display into the new base. If the number cannot be represented in the new base in 10 digits, the calculator still changes base, but it displays an "Er2" error message. Clear the error by pressing [ON/C].

If you convert a numbers containing a fraction from decimal to another base, the fraction will be truncated.

Example: Convert the decimal number 123 into binary, octal, and hexadecimal base.

Press:	[2ndF] [→DEC]	123	The decimal number.
	[2ndF] [→BIN]		
Result:	→BIN	1111011.b	Binary form.
Press:	[2ndF] [→OCT]		
Result:	→OCT	173.o	Octal form.
Press:	[2ndF] [→HEX]		
Result:	→HEX	7b.H	Hexadecimal form.

Keep the following rule in mind when converting from binary, octal, or hexadecimal base to decimal: If the alternate base number displayed is greater than half the maximum value that can be represented in the 10 display digits, the calculator considers the decimal equivalent to the negative.

USING THE BOOLEAN FUNCTIONS

The calculator enables you to perform calculations using the boolean functions **NOT, AND, OR, XOR** and **XNOR,** These functions are available in binary, octal, and hexadecimal bases. When in binary, octal, or hexadecimal, the boolean function becomes the only function of its key. The normal function of the key is inactive.

Example: Calculate 57 **AND** E6 in hexadecimal.

Press: [2ndF] [→HEX]

57 [AND] E6 [=]

Result: 46.H

The boolean functions operate on the number in the display as if it had 10 digits. If the number actually has less than 10 digits, the calculator internally pads the number with leading zeros, though these leading zeros are not displayed. This internal 10 digit number is then used in later calculations.

Example: Calculate **NOT** (FFF) in hexadecimal. This actually calculates **NOT** (0000000FFF).

Press: [2ndF] [→HEX]

[NOT] FFF [=]

Result: FFFFFFF000.H

Fractional Operations

The calculator enables you to convert the fraction format between a mixed fraction and an improper fraction as well as from a fraction to a decimal. A decimal or an exponent cannot be converted to a fraction.

- Up to 6 digits of a numerator and up to 3 digits of a denominator can be used.
- In a mixed fraction, up to 3 digits of integer, numerator, and denominator can be used for each.
- Up to ten digits including integer, numerator, denominator, and symbol ⌜ can be used.
- When the absolute value of a number is out of 1 / 999 through 998999 / 999 or the number of digits exceeds 10, the number is converted to and displayed in a decimal.

Example: Calculate $3\frac{1}{2}+\frac{4}{3}$.

Press: [ON/C] [2ndF] [→DEC] 3 [a b/c] 1 [a b/c] 2 [+] 4 [a b/c] 3 [=]

Result: 4 ⌜ 5 ⌜ 6. $\left(4\frac{5}{6}\right)$

Press: [a b/c]

Result: 4.833333333

Press: [2ndF] [d/c]

Result: 29 ⌜ 6. $\left(\frac{29}{6}\right)$

Example: Calculate $\sqrt[3]{2\frac{8}{9}}$.

Press: [ON/C] [2ndF] [$\sqrt[3]{}$] 2 [a b/c] 8 [a b/c] 9 [=]

Result: 1.424219561

Chapter 3:
Calculations Using Complex Numbers

This chapter tells you how to use your Sharp calculator for arithmetic with complex numbers.

Select the complex numbers mode by pressing [MODE] 1. When you are in CPLX mode, the indicator triangle points to **1: CPLX** above the display. Exit from CPLX mode by pressing [MODE] again to select a different mode.

Calculating in Complex Mode

The calculator enables you to add, subtract, multiply, and divide complex numbers. It also lets you change between two coordinate systems used to represent complex numbers. You can perform mathematical functions on either the real or imaginary parts of complex numbers, but not on both parts of the number at once.

The temporary, and last answer memories are inactive in CPLX mode. Constant calculations are also not available. If a complex value is stored in the independent memory (M), the value of the imaginary part is cleared by mode switching.

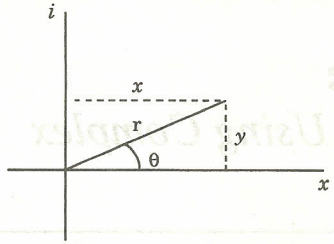
DISPLAY OF CALCULATION RESULT

You can use rectangular coordinates mode ($x + yi$ format) and polar coordinates mode ($r\angle\theta$ format) to display the calculation result in CPLX mode.

- Rectangular coordinates mode: Set by [2ndF] [→*xy*]. (*xy* symbol appears.)
- Polar coordinates mode: Set by [→*rθ*]. ($r\theta$ symbol appears.)

Entering Complex Numbers

Complex numbers can be represented in either *rectangular* or *polar* coordinate form.



In polar coordinates, complex numbers are usually represented using the notation ($r\angle\theta$), where r and θ are respectively a constant multiplier and an imaginary exponent of the number e:

$$(r\angle\theta) = re^{\theta i}$$

You can use either rectangular coordinates format or polar coordinates format for entering values.

- Rectangular coordinates format: real part x [+] imaginary part y [i] (or real part x [+] [i] imaginary part y)
- Polar coordinates format: absolute value r ∠ argument θ when the imaginary part y or the argument θ is 0, calculation is performed as a real number operation.

Example: Enter the complex number 11 + 7i.

Press: [MODE] 1 Select CPLX mode.

11 [+] 7 [i] [=]

Result: 11. →

- You can display the entered contents by pressing [←→].

Press: [←→]

Result: ←+ 7.*i*

CPLX Mode Calculations

Example: Calculate (3 + 2i) × (3 − 4i).

Press: [(] 3 [+] 2 [i] [)] [×] [(] 3 [−] 4 [i] [=]

Result: 17. → The real part.

Press: [←→]

Result: ← − 6.*i* The imaginary part.

Example: Calculate $\frac{1}{1+i}+(1-i)^2$

Press: [(] 1 [+] [i] [)] [2ndF] [x^{-1}] [+]
[(] 1 [−] [i] [)] [x^2] [=]

Result: 0.5 → The real part.

Press: [←→]

Result: ← −2.5i The imaginary part.

Example: Calculate (2 ∠ 30)+(4 ∠ 60).

Press: [ON/C] [→rθ] (r θ mode setting.)

2 [∠] 30 [+] 4 [∠] 60 [=]

Result: 5.818625822 → This is the value r.

Press: [←→]

Rexult: ←∠50.10390936 This is θ.

Example:
$$\begin{array}{r} 2+3i \\ -4+5i \\ +)\,6+7i \\ \hline \end{array}$$

Press: [ON/C] 0 [STO] [M] [2ndF] [→xy] (xy mode setting.)

2 [+] 3 [i] [M+] 4 [+/−] [+] 5 [i]

[M+] 6 [+] 7 [i] [M+] [RCL] [M]

Result: M 4. → The real part.

Press: [←→]

Result: ←+ 15.*i* The imaginary part.

Complex Coordinate Conversions

The calculator enables you to easily convert between the rectangular and polar coordinate representations of a complex number. In polar coordinates, a complex number is entered in $r\angle$ format. (r: absolute value, θ : argument)

· When the argument is 0, calculation is performed as a real number operation.

CONVERTING FROM RECTANGULAR TO POLAR

Before performing a complex coordinates conversion, make sure that [MODE] 1 has been selected.

Use the angular unit **DEG** in the following example.

Example: Convert the complex number 3+ 2i to the equivalent polar coordinates representation.

Press: [→rθ] (r θ mode setting)

Press: 3 [+] 2 [i] [=]

Result: 3.605551275→ This is the value r.

Press: [←→]

Result: ← ∠ 33.69006753 This is θ.

This can be written (approximately) as $3.606e^{33.69i}$.

CONVERTING FROM POLAR TO RECTANGULAR

Example: Convert $6.5e^{-4i}$ to rectangular form.

Press: [2ndF] [→xy] (xy mode setting)

Press: 6.5 [∠] [+/-] 4 [=]

Result: 6.484166327 The real part.

Press: [←→]

Result: ← −0.453417079 *i* The imaginary part.

· In CPLX mode, the function keys [x^2] and [x^{-1}] can be used.

Chapter 4:
Three-Variable Linear Equations

This chapter describes using your calculator's 3-VLE mode to solve three-variable linear equations.

The Three Equations

3-VLE mode solves simultaneous equations of the form:

$$\begin{aligned} a_1x + b_1y + c_1z &= d_1 \\ a_2x + b_2y + c_2z &= d_2 \\ a_3x + b_3y + c_3z &= d_3 \end{aligned}$$

where x, y, and z are unknown.

These equations can also be written in matrix form:

$$\begin{pmatrix} a_1 b_1 c_1 \\ a_2 b_2 c_2 \\ a_3 b_3 c_3 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} d_1 \\ d_2 \\ d_3 \end{pmatrix}$$

In 3-VLE mode, you just key in the known values in the correct order, and the calculator automatically solves for *x*, *y*, and z. The calculator also finds the determinant of the matrix.

If the determinant of the matrix equals zero, then *x*, *y*, and z cannot be solved, and the calculator displays an error "Er2".

Press the [ON/C] key to clear the error.

Solving 3-D Linear Equations

Set the calculator to 3-VLE mode by pressing [MODE] 2.

THE 3-VLE KEYS

The temporary, independent, and last answer memories are inactive in 3-VLE mode. In addition, the following keys are not available:

- [→rθ] and [2ndF] [→xy]
- [2ndF] [RANDOM]
- [M+], and [2ndF] [M−]

The [=] key assumes the function of the [ENT] key, and is used to enter the known values of your equations.

ENTERING THE KNOWN VALUES

In 3-VLE mode, the calculator prompts you for each of the 12 known values from your system of simultaneous equations. You enter values using the [ENT] key, as follows:

- When you enter 3-VLE mode, the calculator displays the prompt **a1?**. Enter the value of **a1**, and press [ENT].
- The prompt **b1?** appears. Enter the value of **b1**, and press [ENT].
- The prompt **c1?** appears. Enter the value of **c1**, and press [ENT].
- The prompt **d1?** appears. Enter the value of **d1**, and press [ENT].

This procedure is repeated until all 12 known values have been entered.

You must enter zeros for any missing terms in your equations. For example, if your first equation is $3x + 5z = 17$,
you would use **a1** = 3, **b1** = 0, **c1** = 5, and **d1** = 17.

DISPLAYING THE SOLUTION VECTOR

When you press [ENT] after entering the value of d3, the calculator calculates and displays the value of x. Display the values of y, z, and the determinant by pressing [ENT]. An indicator (**x**, **y**, **z**, or **det**) appears with each of the displayed values to identify it.

A QUICK EXAMPLE OF A 3-VLE SOLUTION

Try the following example.

Example: Solve $\begin{pmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 1 \\ -1 \\ 1 \end{pmatrix}$

Press:	[MODE] 2	Select 3-VLE mode.
	1 [ENT] 1 [ENT] 0 [ENT] 1 [ENT]	
	0 [ENT] 1 [ENT] 1 [ENT] 1 [+/−] [ENT]	
	1 [ENT] 0 [ENT] 1 [ENT] 1 [ENT]	
Result:	**x** 1.5	
Press:	[ENT]	
Result:	**y** −0.5	
Press:	[ENT]	
Result:	**z** −0.5	
Press:	[ENT]	
Result:	**det** 2.	

VIEWING OR CHANGING THE VALUES YOU ENTERED

After solving a 3-VLE problem, if you immediately press [ENT], the calculator prompts for entry of the constants again, starting with **a1**. The display shows the previous value entered for each of the constants.

You can accept the previously entered values by pressing [ENT], or you can enter new values. The calculator then solves the 3-VLE equation as before. In this way, you can view and verify the values you enter. Or, if you have a similar problem to solve that requires changing just a few of the constants, you can change only those constants.

If you press [MODE] 2 or [2ndF] [CA], all entered values are cleared and the calculator prompts for entry of a1.

It the values of c1, c2 and a3, b3, c3, d3 are entered as 0. simultaneous linear equations with two unknowns can also be solved.

Chapter 5:
Calculating in Statistics Mode

This chapter describes your Sharp calculator's statistical features, and explains how to use STAT mode to calculate:

- standard single-variable statistics
- standard two-variable statistics
- regressions using linear, quadratic, exponential, logarithmic, power, and inverse functions

Enter STAT mode 1 by pressing MODE 3.

STAT Mode and Options

Enter STAT mode by pressing MODE 3. The calculator is in STAT mode when the triangle indicator points to **3:STAT** (printed above the display).

Once you are in STAT mode, the prompt **?0–6** is displayed, asking you to select one of the seven statistics options shown below.

Option	Function	Option	Indicator
0	Single-variable statistics	**0:SD**	**ST0**
1	Linear regression	**1:a+bx**	**ST1**
2	Quadratic regression	**2: ..+cx²**	**ST2**
3	Exponential regression	**3: e^x**	**ST3**
4	Logarithmic regression	**4: lnx**	**ST4**
5	Power regression	**5: ax^b**	**ST5**
6	Inverse regression	**5: 1/x**	**ST6**

Select a statistics option as follows:

- Press the number key (0–6) of the option you want. While the **?0–6** prompt is in the display, the calculator will only recognize the digit keys 0 through 6.
- When you have selected an option, the indicator for that option (given in the previous table) appears at the left end of the display.

The STAT mode and the option you're using are retained if the calculator is turned off or shuts itself off. You can exit STAT mode by pressing MODE 0, 1, 2, or 3.

To change the statistics option, exit STAT mode by pressing MODE, reselect the STAT mode by pressing 3, and choose a new option by pressing the number of the option you want. Remember that when you press the MODE key, all previously entered statistical data and results are cleared.

Statistics Memory

Statistical data and results are retained when the calculator is turned off or shuts itself off, but are cleared when you change modes.

The calculator's temporary and last answer memories are not available in STAT mode, and are cleared when you enter STAT mode. The independent memory is also not available. A number previously stored to the independent memory is not lost, however, and becomes available when you leave STAT mode.

CLEARING STATISTICS MEMORY

There are two ways to clear statistics memory. While using an option in STAT mode, you can get a fresh start by pressing 2ndF CA. This erases the stored data and results.

The second way to clear statistics memory is to exit STAT mode. When you press the MODE key, the statistics memory is cleared. If you want to continue to use the STAT mode, you must re-enter STAT mode and select a statistics option.

Since statistical memory is retained when the calculator is turned off, it is a good idea to clear statistics memory when you turn the calculator on if STAT mode has already been selected. Do this by pressing 2ndF CA.

Single-Variable Statistics

The calculator can quickly compute standard single-variable statistical functions.

ENTERING SINGLE-VARIABLE DATA

Before you begin, clear the statistics memory by pressing [2ndF] [CA]. Enter data using the digit and [DATA] keys. Each time [DATA] is pressed, the calculator displays the total number of items you've entered.

The calculator automatically recalculates statistics each time you enter data. You can display intermediate values each time you enter a new data value as described in the upcoming section DISPLAYING RESULTS.

Example: Enter three data items: 4, 6, and 2.

Press:	[MODE] 30	Select the single-variable statistics option.
	4 [DATA] 6 [DATA] 2 [DATA]	
Result:	n 3.	Three data items have been entered.

If you press only [DATA] just after pressing [DATA]. the number that has been entered before the former [DATA] is entered again.

WEIGHTED DATA (REPEATING DATA ENTRIES)

Enter repeated data as follows:

- Enter the value of the data.
- Press [×] (the multiplication key).
- Enter the number of times that value occurs.
- Press [DATA].

Repeat this procedure for all data items.

- If you enter weighted data and the data is an expression, use parentheses for the expression. [(] data [)] [×] number of times [DATA].

Example: Enter the data values: 5, 9, 5, 2, 5, 9, 9, and 5. This data can be rewriten as:

Value	Number of Occurrences
2	1
5	4
9	3

Press:	[MODE] 30	Select the single-variable statistics option.
	2 [DATA] 5 [×] 4 [DATA] 9 [×] 3 [DATA]	
Result:	n 8.	

CORRECTING SINGLE-VARIABLE DATA

If you make a mistake while entering data, you can correct your mistake using the clear data key [2ndF] [CD] , as follows:

- Key in the incorrect data.
- Press [2ndF] [CD]. This deletes the entry from the stored statistical data, and corrects the calculated statistics.

Example: Enter the following data:

5, 5, 5,

18, 18,

3, 3, 3, 3, 3, 3, 3

Press:	[MODE] 30	
	5 [×] 3 [DATA]	
	18 [×] 2 [DATA]	
	3 [×] 4 [DATA]	By mistake.
Result:	n 9.	
	3 [×] 4 [2ndF] [CD]	
Result:	n 5.	The four incorrect values have been deleted.
	3 [×] 7 [DATA]	To correct.
Result:	n 12.	

Before pressing [DATA], you can clear an item by pressing [ON/C] and correct a number by pressing [→] key.
If you press [2ndF] [CD] just after pressing [DATA], the number that has been entered before the [DATA] is cleared.

DISPLAYING RESULTS

The calculator continually updates the statistics as you enter data. You can recall results using [RCL] and one of the statistics keys. For single-variable statistics, the following results can be recalled with the keys shown.

1. [RCL] [$\bar{x}$] Mean value.
2. [RCL] [sx] Sample standard deviation.
3. [RCL] [σx] Population standard deviation.
4. [RCL] [n] Number of data items.
5. [RCL] [Σx] Sum of all data.
6. [RCL] [Σx^2] Sum of the squares.

Example: Find the sum of the data items from the previous example.

Press: [RCL] [Σx]

Result: Σx 72.

Example: Find the sample standard deviation sx from the example above.

Press: [RCL] [sx]

Result: sx 5.672902095

COMPUTING STANDARD SINGLE-VARIABLE STATISTICS

The calculator enables you to calculate the six single variable statistics.

There are two standard deviation functions on the calculator: sx and σx. Use sx for the standard deviation of a *sample*. If you are sampling a population, and you wish to generalize about the population at large, you should use sx. If you are computing statistics from an *entire* population, use σx for the standard deviation.

Example: What are the mean and population standard deviation of the following data? Calculate to two decimal places.
78, 92, 83, 90, 57, 95, 88, 83, 81, 85, 89

Press:	[MODE] 30		Select statistics mode 0.
	[2ndF] [FSE]		Until **FIX** appears.
	[2ndF] [TAB] 2		Select 2 decimal places.
	78 [DATA] 92 [DATA] 83 [DATA]		
	90 [DATA] 57 [DATA] 95 [DATA]		
	88 [DATA] 83 [DATA] 81 [DATA]		
	85 [DATA] 89 [DATA]		
Result:	n	11.00	
Press:	[RCL] [$\bar{x}$]		
Result:	$\bar{x}$	83.73	The mean of the data.
Press:	[RCL] [σx]		
Result:	σx	9.71	Population standard deviation.

Two-Variable Statistics

The calculator enables you to compute standard statistical functions for two-variable data, as well as six types of regression. The statistics options 1 to 6 shown earlier in STATISTIC MODE AND OPTIONS use two-variable data.

By selecting one of these 6 options you are selecting the type of regression you want to use.

ENTERING TWO-VARIABLE DATA

Enter data pairs as follows:

· Enter x.
· Press (x,y) (the *primary* function of the STO key in STAT mode).
· Enter y.
· Press DATA.

As with single-variable data, you can display intermediate results before all your data is entered.

Example: Enter the following data:

x	y
500	6.38
1000	3.22
1500	3.35
2000	2.75
2500	2.87

Press: MODE 31 Select the linear regression option.

500 (x,y) 6.38 DATA

1000 (x,y) 3.22 DATA

1500 (x,y) 3.35 DATA

2000 (x,y) 2.75 DATA

2500 (x,y) 2.87 DATA

Result: n 5.

WEIGHTED DATA (REPEATING DATA ENTRIES)

You make repeated entries in two-variable statistics much as you do for single-variable data:

· Enter x.
· Press (x,y).
· Enter y.
· Press ×.
· Enter the number of occurrences.
· Press DATA.

Repeat this procedure for all data items. Notice that the display keeps a running total of the number of pairs of data items entered.

Example: Enter the following data:

x	y	Occurrences
17.4	3.7	35
19.2	4.8	48
12.6	4.2	27

Press: MODE 31 Select the linear regression option.

17.4 (x,y) 3.7 × 35 DATA

19.2 (x,y) 4.8 × 48 DATA

12.6 (x,y) 4.2 × 27 DATA

Result: n 110.

CORRECTING TWO-VARIABLE DATA

As with single-variable data, you can correct mistakes by using the 2ndF CD key as follows:

· Enter the incorrect x value.
· Press (x,y).
· Enter the incorrect y value.
· Press 2ndF CD .

You can now enter the correct data.

Example: Enter the following two-variable data.

x	y	Occurrences
5	10	3
6	15	4
7	20	3

Press: MODE 31 Selecting option 1 chooses the linear model for regression.

	5 (x,y) 10 ⊠	
	3 DATA	
	6 (x,y) 15 ⊠	
	4 DATA	
	7 (x,y) 30 ⊠	
	3 DATA	A mistake!
	7 (x,y) 30 ⊠	
	3 2ndF CD	To clear the error.
	7 (x,y) 20 ⊠	
	3 DATA	The correction.
Result:	n 10.	

DISPLAYING RESULTS

you can recall two-variable statistical results using the RCL key just the same as with single-variable data.

For two-variable statistics, the following results can be recalled.
a, b, c, r, $\bar{x}$, sx, σx, $\bar{y}$, sy, σy, n, Σx, Σx^2, Σxy, Σy, Σy^2

Example: Find the sum of the squares of y data (Σy^2) from the previous example.

Press:	RCL Σx^2	To display Σy^2.
Result:	Σy^2 2400.	

COMPUTING STANDARD TWO-VARIABLE STATISTICS

The standard two-variable statistics functions include all of the single-variable statistics plus the following:

a — a in your selected regression model equation. For example, a is the Y-intercept in the linear regression formula y = a + bx.

b — b in your selected regression model equation. For example, b is the slope in the linear regression formula y = a + bx.

r — Correlation coefficient.

c — This a result for the quadratic model only, It is c in the equation $y = a + bx + cx^2$.

$\bar{y}$ — Mean of the y values.

sy — Sample standard deviation of y values.

σy — Population standard deviation of the y values.

Σxy — Sum of the pair products xy ($= x_1y_1 + x_2y_2 + \ldots$)

Σy — Sum of the y values.

Σy^2 — Sum of the squares of the y values.

x' — Calculates a predicted x for a given y using your selected regression model.

y' — Calculates a predicted y for a given x using your selected regression model.

The calculator uses linear regression formulas for exponential, logarithmic, power, and inverse regression calculations.
Entered data, x and y, are transformed into X and Y, respectively, as shown in the following table.

Type	Regression formula	Data transformation		Transformed formula
		X	Y	
Linear	$y = a + bx$	x	y	Y=a+bX
Exponential	$y = a \cdot e^{bx}$	x	$\ln y$	Y=lna+bX
Logarithmic	$y = a + b \cdot \ln x$	$\ln x$	y	Y=a+bX
Power	$y = a \cdot x^b$	$\ln x$	$\ln y$	Y=lna+bX
Inverse	$y = a + b\frac{1}{x}$	$\frac{1}{x}$	y	Y=a+bX

Thus, the values of $\bar{x}$, Σx, Σx^2, sx, σx, $\bar{y}$, Σy, Σy^2, Σxy, sy, and σy are determined from the transformed data (X and Y), instead of the entered data (x and y).

CORRELATION COEFFICIENT

The statistic r called the *correlation coefficient* tells you how closely a particular regression equation fits your data. The correlation coefficient ranges from − 1 to 1.

The correlation coefficient (r) is computed for all the regression epuations except quadratic equations, available on the calculator.

ESTIMATING VALUES OF x OR y

Once you have entered a body of data, the calculator allows you to use that data to estimate a value of y (called y') from a known value of x, and a value of x (called x') from a known value of y. (Keep in mind that the estimated values x' and y' are only accurate if the correlation coefficient of your data is close to 1 or − 1.)
Estimate y' for a known value of x by entering x and pressing [2ndF] [y']. Estimate x' for a known value of y by entering y and pressing [2ndF] [x'].

Example: Given the following data and using the linear model, determine the correlation coefficient r, and estimate y' for $x = 90$, and x' for $y = 80$.

x	y
82	79
53	50
61	87
74	96
51	73
51	75

Press:	[MODE] 31	Select the linear regression option.
	[2ndF] [FSE]	Until **FIX** is displayed.
	[2ndF] [TAB] 2	For 2 decimal places.
	82 [(x,y)] 79 [DATA]	
	53 [(x,y)] 50 [DATA]	
	61 [(x,y)] 87 [DATA]	
	74 [(x,y)] 96 [DATA]	
	51 [(x,y)] 73 [DATA]	
	51 [(x,y)] 75 [DATA]	

Result:	n 6.00	
Press:	[RCL] [n]	
Result:	r 0.55	The correlation coefficient r.

Now estimate y' for $x = 90$.

Press:	90 [2ndF] [y']	
Result:	y 94.96	

Estimate x' for $y = 80$.

Press:	80 [2ndF] [x']	
Result:	x 67.10	

Regressions

The calculator enables you to use six types of regression to compute statistics. Each regression option assumes a different relation between the independent variable x and the dependent variable y. Be sure the option you select uses a relationship that is appropriate for your particular problem.

Type of regression	Equation	Option	Mode
Linear regression	$y = a + bx$	ST1	[MODE] 31
Quadratic regression	$y = a + bx + cx^2$	ST2	[MODE] 32
Exponential regression	$y = ae^{bx}$	ST3	[MODE] 33
Logarithmic regression	$y = a + b \ln x$	ST4	[MODE] 34
Power regression	$y = ax^b$	ST5	[MODE] 35
Inverse regression	$y = a + \frac{b}{x}$	ST6	[MODE] 36

· If you perform a regression using a, b, and c, up to 1 number and up to 8 operations can be stored.

LINEAR, EXPONENTIAL, LOGARITHMIC, POWER, AND INVERSE REGRESSIONS

For all these regressions, correlation coefficient (r) is computed.

Example: Recall a and b for the previous linear model in ESTIMATING VALUES OF x OR y.

Press:	RCL a		Recall a.
Result:	a	36.17	
Press:	RCL b		Recall b.
Result:	b	0.65	

Example: Find a, b, and correlation coefficient r for the following data using the logarithmic model. Estimate y' for $x = 70$ and $x = 250$.

n	1	2	3	4	5	6
x	5	10	20	40	80	160
y	5.8	9.4	13.0	16.3	18.8	21.1

Two solutions may exist for the estimated y' in the logarithmic regression. Recall each solution by pressing 2ndF y'.

Press:	MODE 34		Select the logarithmic regression option.
	FSE		Until **FIX** is displayed.
	2ndF TAB 3		Set 3 decimal places.
	5 (x,y) 5.8 DATA		
	10 (x,y) 9.4 DATA		
	20 (x,y) 13 DATA		
	40 (x,y) 16.3 DATA		
	80 (x,y) 18.8 DATA		
	160 (x,y) 21.1 DATA		
Result:	n	6.000	
Press:	RCL a		Recall a.
Result:	a	−0.812	
Press:	RCL b		
Result:	b	4.452	

Estimate y' for $x = 70$:

Press:	70 2ndF y'	
Result:	y	18.101

Estimate y' for $x = 250$:

Press:	250 2ndF y'	
Result:	y	23.768

QUADRATIC REGRESSIONS

No correlation coefficient (r) is computed for a quadratic regression.

Two solutions may exist for the estimated x' in the quadratic regression. Recall the two solutions by pressing 2ndF x' twice.

Example: Assuming a quadratic relationship between the x and y data below, estimate x' for $y = 6$.

n	1	2	3	4	5	6
x	1	3	5	7	9	11
y	3	13	31	50	82	133

Press:	MODE 32		Select the quadratic regression option.
	2ndF FSE		Until **FIX** is displayed.
	2ndF TAB 6		
	1 (x,y) 3 DATA 3 (x,y) 13 DATA		
	5 (x,y) 31 DATA 7 (x,y) 50 DATA		
	9 (x,y) 82 DATA 11 (x,y) 133 DATA		
Result:	n	6.000000	

Estimate the two values of x'.

Press:	6 2ndF x'	
Result:	x1	1.642739 →
Press:	←→	
Result:	←x2	−0.382969

Chapter 6:
Applications

The chapter contains solved problems from a number of fields that demonstrate the power of your Sharp calculator.

Physics

GEOSYNCHRONOUS ORBITS

The orbit of a satellite about the earth is geosynchronous if the period of the orbit matches the period of the earth's rotation.

Example: At what distance from the center of the earth can geosynchronous orbit occur?

The period of an orbit is described by the equation:

$$T^2 = \frac{4\pi^2}{GM} r^3$$

Where: T = Period of orbit

G = Gravitational constant

M = Mass of the earth (5.976×10^{24} kg)

r = Distance (radius) between the satellite and the center of the earth

Rearranging the equation to solve for r^3:

$$r^3 = \frac{GM\,T^2}{4\pi^2}$$

The earth rotates once every 23 hours, 56 minutes, and 4.09 seconds. Convert this time to seconds:

Press: [MODE] 0 23 [D°M'S] 56 [D°M'S] 4 [D°M'S] 9 [2ndF] [→DEG] [×] 60 [x^2] [=]

Result: 86164.09 This is T.

The limiting number in your data (the mass of the earth) has only four significant digits. Select the scientific display format with **three** decimal place.

Press: [2ndF] [FSE] Until **SCI** appears.
[2ndF] [TAB] 3

Result: 8.616^{04}

Press: [STO] [M] Store this answer in M.

Solve the equation for r.

Press: [CNST] 02 [×] 5.976 [Exp] 24 [×] [RCL] [M] [x^2] [÷] [(] 4 [×] [2ndF] [π] [x^2] [)] [=]

Result: 7.499^{22} This is r^3.

Press: [2ndF] [$\sqrt[3]{}$] [=]

Result: 4.217^{07} In meters.

Convert this to miles. To use the conversion to miles, you must first convert the distance to kilometers.

Press: [÷] 1000 [=] [2ndF] [CONV] 08

Result: 2.620^{04}

Geosynchronous orbit occurs at a radius of 26,200 miles from the center of the earth.

TWINKLE, TWINKLE, LITTLE STAR

The *apparent magnitude* of a star tells how bright it appears. The apparent brightness of a star is determined by how far away the star is and the luminosity of the star.

Since stars are seen from greatly different distances, their luminosities must be standardized in order to be compared. This is done using a quantity called the *absolute magnitude*. The absolute magnitude of a star tells how bright that star would appear if viewed from a distance of 10 parsecs (about 32.6 light years). If the absolute magnitude of two stars is known, the ratio of their luminosities is:

$$\log \frac{L_2}{L_1} = 0.4(M_1 - M_2)$$

Where: M_1 = the absolute magnitude of the first star

M_2 = the absolute magnitude of the second star

L_1 = the luminosity of the first star

L_2 = the luminosity of the second star

Example: What is the ratio of the sun's luminosity to that of a star having an absolute magnitude of 2.89? (The sun's absolute magnitude is 4.8.)

Rearranging the above equation:

$$\frac{L_2}{L_1} = 10^{.4(M1 - M2)}$$

In this case, $M_2 = 2.89$.

Press: MODE 0 2ndF 10^x (. 4) 4.8 − 2.89 =

Result: 5.807644175 The star is nearly 6 times as luminous as the sun.

Example: A second star has only 0.0003 the luminosity of the sun. What is its absolute magnitude?

Rearranging the first equation to solve for M_2:

$$M_2 = M_1 - \frac{\log \frac{L_2}{L_1}}{0.4}$$

In this case, $\frac{L_2}{L_1} = .0003$.

Press: ON/C 4.8 − log .0003 ÷ . 4 =

Result: 13.60719686

RADIOACTIVE DECAY

Carbon–14 (^{14}C) is a naturally occurring radioactive isotope of carbon, used in the carbon dating process. Because carbon–14 decays at a steady rate, it is possible to determine the age of a once living specimen by measuring the remaining percentage of ^{14}C it contains.

The mass of a ^{14}C contained in a sample changes according to this equation:

$$M = M_0 e^{-kt}$$

Where: M = Mass of ^{14}C at time t

M_0 = Original mass of ^{14}C

k = Constant of Decay

(for ^{14}C, $k = 1.2118 \times 10^{-4}$ year^{-1})

t = Time in years

Example: You have a 100kg sample of ^{14}C, which you leave to decay for 10,000 years. How much ^{14}C remains? Solve for M.

Since your data is three significant figures, select the scientific display format with two decimal places.

Press: ON/C 2ndF FSE Until SCI appears.

2ndF TAB 2

100 2ndF e^x +/− (1.2118 Exp +/− 4 ×

10000 =

Result: 2.98^{01} 29.8 kg.

Example: The half-life of an element is the time required for half of the mass to decay away. What is the half-life of (^{14}C)?

At the half-life of your 100kg sample, 50kg remains. This remaining mass is M in the decay equation given in the previous example. Solve for t.

$$50 \text{ kg} = 100 \text{ kg } e^{-kt}$$

$$e^{-kt} = \frac{50}{100}$$

$$-kt = \ln\left(\frac{50}{100}\right)$$

$$t = \frac{-\ln\left(\frac{50}{100}\right)}{k}$$

Press: ON/C +/− ln (50 ÷ 100) ÷ 1.2118

Exp +/− 4 =

Result: 5.72^{03} 5720 years.

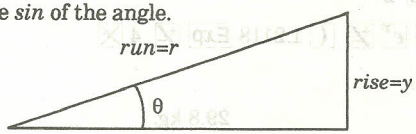
Engineering

ANGLE VS. PERCENT GRADE

Example: You have two friends who are arguing about whose street is the steeper one. One found out from the city engineer that his street was built on a 6% grade. The other measured the angle of his street to be 3 degrees. Which street is steeper ?

The problem can be solved by converting either measurement into terms of the other measurement and then comparing the results. Let's convert the percent grade into degrees of angle.

Grade equals *rise over run*. Percent grade is grade times 100, (expressed as a percent). Notice that rise over run is the same as the *sin* of the angle.



$$\text{SIN}(\theta) = \frac{y}{r} = \frac{\text{rise}}{\text{run}}$$

The equation is: $\text{SIN}(\theta) = 6\%$ or: $\theta = \text{SIN}^{-1}(6\%)$

Use the [%] key when entering percent values. Make sure **DEG** is selected. To convert a 6% grade to degrees:

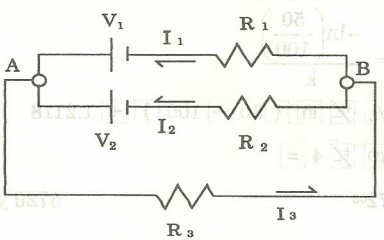
Press: [ON/C] [2ndF] [sin⁻¹] 6 [%] [=]

Result: 3.439812768 In degrees.

The 6% grade can be rounded to a 3.44° angle. It is the steeper street. Your friends can stop arguing.

ELECTRIC CIRCUIT (KIRCHHOFF'S LAWS)

Example: What are the currents (I_1, I_2, I_3) in this circuit?



Given that the components of the circuit have the values:

$V_1 = 8$ volts

$V_2 = 4$ volts

$R_1 = 5$ ohms

$R_2 = 2$ ohms

$R_3 = 2$ ohms

Kichhoff's Law for circuit junctions states that the sum of the currents entering a junction must be the same as the sum of the currents leaving the junction. In this example, at junction A,

$$I_1 + I_2 - I_3 = 0 \qquad \text{(equation 1)}$$

Kichhoff's Law for a closed circuit states that the sum of the voltage changes around any closed circuit must equal zero. Taking the closed loop that includes V_1 and R_3:

$$V_1 - I_1R_1 - I_3R_3 = 0$$

or: $$I_1R_1 + I_3R_3 = V_1 \qquad \text{(equation 2)}$$

Around the closed loop that includes V_2 and R_3:

$$V_2 - I_2R_2 - I_3R_3 = 0$$

or: $$I_2R_2 + I_3R_3 = V_2 \qquad \text{(equation 3)}$$

Grouping equations 1, 2, and 3 and substituting known voltages and resistances gives:

$$I_1 + I_2 - I_3 = 0$$

$$5I_1 + 2I_3 = 8$$

$$2I_2 + 2I_3 = 4$$

We now have three equations containing three unknowns. The calculator's **3-VLE** mode can solve this system of equations quickly.

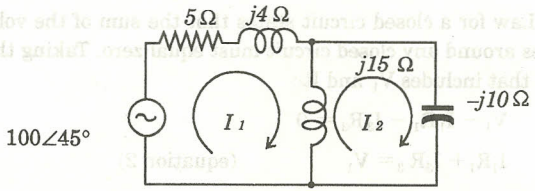
Press: [MODE] 2

Press: 1 [ENT] 1 [ENT] [+/-] 1 [ENT] 0 [ENT]
5 [ENT] 0 [ENT] 2 [ENT] 8 [ENT]
0 [ENT] 2 [ENT] 2 [ENT] 4 [ENT]

Result:	x	1	The value of I_1.
Press:	ENT		
Result:	y	0.5	The value of I_2.
Press:	ENT		
Result:	z	1.5	The value of I_3.

ELECTRIC CIRCUIT II (MESH CURRENT METHOD)

Example: What is the value of the current I that flows in this circuit?



The mesh current equation for this network becomes as follows:

$$\begin{bmatrix} 5+i19 & -j15 \\ -j15 & j5 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 100\angle 45° \\ 0 \end{bmatrix}$$

Hence, the current I_1 can be solved by the following equation:

$$I_1 = \frac{\begin{vmatrix} 100\angle 45° & -j15 \\ 0 & j5 \end{vmatrix}}{\begin{vmatrix} 5+j19 & -j15 \\ -j15 & j5 \end{vmatrix}}$$

Using the CPLX mode of this calculator, above determinant can be calculated.

Press:	MODE 1	Select CPLX mode. (Use DEG.)
	→rθ	rθ mode setting.
	(100 ∠ 45 × 5 i) ÷	
	(((5 + 19 i) × 5 i) − (⁄ 15 i) x²) =	
Result:	3.776947873 →	The value of r (I_1).
Press:	←→	
Result:	→∠124.1144729	The value of θ (DEG).

The answer is $3.7769\angle 124^\circ$A.

Press:	2ndF →xy	xy mode setting.
Result:	−2.118294209 →	The value of x.
Press:	←→	
Result:	←+3.127005737 $_i$	The value of y.

SELECTING CHARACTERS FOR A RUDIMENTARY COMPUTER

You own a very simple computer. You can display any character by entering that character's code as a hexadecimal number.

The decimal code for letter characters is determined by adding 196 to the number of the letter's place in the alphabet. The code for a would then be 196 + 1 = 197 the code for the 23rd letter of the alphabet would be 196 + 23 = 219, and so forth. Once the decimal code is determined, it must be converted to hexadecimal.

Example: What codes correspond to the letters r and y ? The letter is the 18th letter of the alphabet.

Press:	MODE 0	To place in NORMAL mode.
Press:	2ndF →DEC	Select DEC mode.
	196 + 18 =	
Result:	214.	
	2ndF →HEX	Convert to HEX.
Result:	→HEX d6.H	

Example: What is the code for y ?

Press:	2ndF →DEC	Select DEC mode.

196 [+] 25 [=]

Result: 221.

[2ndF] [→HEX] Convert to HEX.

Result: →HEX dd.H

On this computer, the codes for capital letters are found by subtracting the hexadecimal number 20 from the code for the equivalent lower case letter.

Example: What is the code for Y ?

Press: [2ndF] [→HEX] Select HEX mode.

dd [−] 20 [=]

Result: bd.H In hexadecimal.

Statistics

CHI-SQUARE TEST

The chi-square test (x^2) compares a sample of data to a statistical hypothesis (probability distribution). The chi-square is a "goodness of fit" test that is applicable to nominal scale data (discrete functions). The data are tallies of observations in categories.

To perform the chi-square test, observed values from an experiment are compared to the expected values based on the probability model. The following statistic is calculated and compared to a table of chi-square critical values:

$$x^2 = \Sigma \frac{(f_i - F_i)^2}{F_i} \text{ or, } \Sigma \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

Where: f_i = number of observations for category i

F_i = expected number of observations for category i (based on the statistical model)

Example: You have been culturing a plant with flowers of types P, Q, R, and S. According to Mendel's Laws, the number of each type should conform to the ratio of 9:3:3:1. In you experiment, the results are:

Flower Type:	P	Q	R	S	
Probability Model:	9	3	3	1	= 16
Expected Ration:	$\frac{9}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{16}$	
# Observed:	125	40	42	12	= 219

You want to know if the flowers you have been culturing conform to Mendel's probability model.

This is an analysis of single-variable data. Begin by entering the single-variable option in STAT mode.

Press: [MODE] 30 To enter STAT mode, single-variable option.

You can compute the expected number of flowers in each flower type (F_i) by multiplying the expected ratio for that type by the total number of flowers.

Press: 9 [÷] 16 [×] 219 [=]

Result: 123.1875 Expected number for Type P.

Press: 3 [÷] 16 [×] 219 [=]

Result: 41.0625 Expected number for Type Q and R.

Press: 1 [÷] 16 [×] 219 [=]

Result: 13.6875 Expected number for Type S.

The chi-squared statistics is easily computed in STAT mode. For each flower type (P through S), use the arithmetic operation keys to compute

$$\frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

and enter it as a data item. The chi-squared statistics is the sum of these ($\Sigma\, x$) for the four flower types.

Press: 125 [−] 123.1875 [=] [x^2] [÷] 123.1875 [=]

[DATA]

40 [−] 41.0625 [=] [x^2] [÷] 41.0625 [=]

[DATA]

42 [−] 41.0625 [=] [x^2] [÷] 41.0625 [=]

[DATA]

12 [−] 13.6875 [=] [x^2] [÷] 13.6875 [=]

[DATA]

[RCL] [Σx] To recall the sum of x values.

Result: Σx 0.283612379

Compare this calculated chi-squared with critical values from a standard chi-squared table. The number of *degrees of freedom* is equal to the number of data categories minus 1. The number of categories in this example is 4 (the number of flower types) so the degrees of freedom is 3.

The critical value of chi-squared from the table (95% level of confidence, 3 degrees of freedom) is 7.81. Since your calculated answer is less than this critical value, your experimental results agree with the hypothesis and suggest that your flowers conform to Mendel's probability model.

REGRESSION

The calculator's six regression options enable you to test hypotheses for two-variable data.

Example: In your grocery business, you stock three different colors of apples: red, yellow, and green.

Red apples cost17.4¢ per pound, and you can display 35 pounds. Green apples cost 19.2¢ per pound, and you can display 48 pounds. Yellow apples cost 12.6¢ per pound, and you can display 27 pounds.

Red apples have been averaging 3.7 apples per pound. Green apples have been averaging about 4.8 apples per pound. Yellow apples have been averaging about 4.2 apples per pound.

What is your average cost per pound of displayed apples ($\bar{x}$) and how many apples do you display ?

This is a two-variable statistical problem that assumes a linear relationship between x and y. Key in the cost per pound as x, the apples per pound as y, and the number of displayed pounds as the number of occurrences.

Press: [MODE] 31 Select the linear regression option.

17.4 [(x,y)] 3.7 [×] 35 [DATA]

19.2 [(x,y)] 4.8 [×] 48 [DATA]

12.6 [(x,y)] 4.2 [×] 27 [DATA]

Result: n 110.

As you key this data in, the number n in the display reflects the total number of pounds. After you have the data keyed in, you can obtain the average price per pound of displayed apples.

Press: [RCL] [$\bar{x}$] Recall $\bar{x}$

Result: $\bar{x}$ 17.00727273

You can obtain the number of displayed apples by multiplying the average apples per displayed pound $\bar{y}$ by the number of displayed pounds n.

Press: [RCL] [$\bar{y}$] Recall $\bar{y}$.

Result: $\bar{y}$ 4.302727273

[×] 110 [=]

473.3

This means you usually display between 473 and 474 apples in your store.

Business and Money

BANK INTEREST

The formula for determining the future value of an investment earning a fixed rate of interest is:

$$FV = PV(1 + i)^n$$

Where: FV = Future value

PV = Present value

i = interest rate per period (expressed as a fraction)

n = number of periods

Example: You invest $5,000 in a 4-year note that pays 9 percent interest, compounded quarterly. What is its value after the 4 years ?

Set the calculator for two decimal places (since dollars can only be calculated to two decimal places).

Press: [2ndF] [FSE] Until FIX appears.

[2ndF] [TAB] 2

The total number of periods can be calculated from the number of periods per year (4) and the number of years (4).

$$n = 4 \text{ years} \times \frac{4 \text{ periods}}{\text{year}}$$

$$i = \frac{9\%}{\text{year}} \times \frac{1 \text{ year}}{4 \text{ periods}}$$

The interest rate per period calculation becomes:

$$FV = 5000 \ (1+\frac{0.09}{4})^{4\times4}$$

Press: [MODE] 0 5000 [(] 1 [+] 0.09 [÷] 4 [)] [y^x]

[(] 4 [×] 4 [)] [=]

Result: 7138.11

What would the value be if it were compounded daily ?
This time:

$$n = 4 \text{ years} \times \frac{365 \text{days}}{\text{year}}$$

$$i = \frac{9\%}{365}$$

Press: 5000 [(] 1 [+] 0.09 [÷] 365 [)] [y^x]

[(] 4 [×] 365 [)] [=]

Result: 7166.33

Fun and Games

DRIVE MY CAR

Example: The gas tank of your European car holds 46.2 liters. If gas costs $ .91 per gallon, how much will it cost to fill your tank?

Press: [2ndF] [FSE] Until FIX appears.

[2ndF] [TAB] 2

Press: .91 [×] 46.2 [2ndF] [CONV] 20 [=]

Result: 11.11 It will cost $ 11.11 to completely fill your tank.

Example: It will take you 13 hours and 36 minutes to drive from San Francisco to Portland. If you want to break the trip into three legs of equal length, how long should each leg be?

Press: 13 [D°M'S] 36 [÷] 3 [=]

Result: 4° 32′ 00.00 4 hours and 32 minutes.

THE LOTTERY

Example: The state you live in has two different lotteries. In the first, you must pick 6 digits between 1 and 50, in any order. In the second, you have to pick 5 digits between 1 and 35, but you must pick them in the correct order. Which lottery gives you a better chance of winning?

For the first lottery, your chances of winning are 1 in ${}_{50}C_{6}$:

Press: 50 [nCr] 6 [=]

Result: 15890700.

Your chances of winning the second lottery are 1 in ${}_{35}P_{5}$:

Press: 35 [2ndF] [nPr] 5 [=]

Result: 38955840.

Your chances are better in the first lottery.

Appendix A:
Physical Constants and Metric Conversions

Physical Constants

Recall a physical constant by pressing [CNST] and entering a constant number (01 to 32). The physical constants registered in this calculator are based on the adjusted values from the CODATA (Committee on Data for Science and Technology) of ICSU (International Council of Scientific Unions) of 1986.

Constant	Symbol	Value
01. Speed of light vacuum	c	2.99792458×10^{8} m/sec
02. Gravitational constant	G	6.67259×10^{-11} N·m^2/kg^2
03. Gravitational acceleration	g	9.80665 m/s^2
04. Electron mass	m_e	$9.1093897 \times 10^{-31}$ kg
05. Proton mass	m_p	$1.6726231 \times 10^{-27}$ kg
06. Neutron mass	m_n	$1.6749286 \times 10^{-27}$ kg
07. μ particle mass	m_μ	$1.8835327 \times 10^{-28}$ kg
08. Atomic mass unit	u	$1.6605402 \times 10^{-27}$ kg
09. Electron charge	e	$1.60217733 \times 10^{-19}$ C
10. Planck constant	h	$6.6260755 \times 10^{-34}$ J · s
11. Boltzmann constant	k	1.380658×10^{-23} J/k
12. Magnetic permeability	μ_0	$1.2566370614 \times 10^{-6}$ H/m
13. Dielectric permittivity	ε_0	$8.854187817 \times 10^{-12}$ F/m
14. Classical electron radius	r_e	$2.81794092 \times 10^{-15}$ m
15. Fine structure constant	α	$7.29735308 \times 10^{-3}$
16. Bohr radius	a_0	$5.29177249 \times 10^{-11}$ m
17. Rydberg constant	R_∞	$1.0973731534 \times 10^{7}$ m^{-1}
18. Fluxoid quantum	ϕ_0	$2.06783461 \times 10^{-15}$ Wb

19. Bohr magneton	μ_B	$9.2740154 \times 10^{-24}$ J/T
20. Electron magnet moment	μ_e	$9.2847701 \times 10^{-24}$ J/T
21. Nuclear magneton	μ_N	$5.0507866 \times 10^{-27}$ J/T
22. Proton magnetic moment	μ_P	$1.41060761 \times 10^{-26}$ J/T
23. Neutron magnetic moment	μ_n	$9.6623707 \times 10^{-27}$ J/T
24. μ particle magnetic moment	μ_μ	$4.4904514 \times 10^{-26}$ J/T
25. Compton electron wavelength	λ_c	$2.42631058 \times 10^{-12}$ m
26. Compton proton wavelength	λ_{cp}	$1.32141002 \times 10^{-15}$ m
27. Stefan-Boltzmann constant	σ	5.67051×10^{-8} W/m^2 K^4
28. Avogadro's constant	N_A	6.0221367×10^{23} mol^{-1}
29. Ideal gas volume at STP	Vm	2.24141×10^{-2} m^3/mol
30. Gas constant	R	8.31451 J/mol · K
31. Faraday constant	F	9.6485309×10^4 C/mol
32. Quantum hole resistance	R_H	$2.58128056 \times 10^4 \Omega$

Metric Converrsions

Recall a metric conversion by pressing [2ndF] [CONV] and entering a conversion number (01 to 32). The metric conversion constants are based on the ISO (International Organization for Standardization).

01. inches → centimeters	1 inch	= 2.54 centimeters
02. centimeters → inches		
03. feet → meters	1 foot	= 0.3048 meters
04. meters → feet		
05. yards → meters	1 yard	= 0.9144 meters
06. meters → yards		
07. miles → kilometers	1 mile	= 1.609344 kilometers
08. kilometers → miles		
09. n miles → meters	1 n mile	= 1852 m
10. meters → n miles		

11. acres → square meters	1 acre = 4046.8564224 m^2
12. sequare meters → acres	
13. ounces → grams	1 ounce = 28.349523125 grams
14. grams → ounces	
15. pounds → kilograms	1 pound = 0.45359237 kilograms
16. kilograms → pounds	
17. °F → °C	°F = 1.8 × °C + 32
18. °C → °F	
19. U.S. gallons → liters	1 gal(u.s.) = 3.785411784 liters
20. liters → U.S. gallons	
21. U.K. gallons → liters	1 gal (U.K.) = 4.5460992948 l
22. liters → U.K. gallons	
23. U.S. fluid ounce → milliliters	1 fl.oz (U.S.)=29.5735295625 ml
24. milliliters → U.S. fluid ounce	
25. U.K. fluid ounce → milliliters 1	fl. oz (U.K.)=28.413120593 ml
26. milliliters → U.K. fluid ounce	
27. Joules → calories	1 Joule = 0.238920081232 calories
28. calories → Joules	
29. horsepower → kilowatts	1 hp = 0.745699871582 kW
30. kilowatts → horsepower	
31. French horsepower → kilowatts	1 ps = 0.73549875 kw
32. kilowatts → French horsepower	

Appendix B:
Calculation Ranges and Error Conditions

In general, your Sharp calculator produces every reasonable calculation given a 10-digit accuracy and 2-digit limit for exponents. The calculator can display integers between − 9999999999 and 9999999999.

Real numbers can be displayed to a precision of 10 digits, so that $10^{-99} \leqq |x| \leqq 9.999999999 \times 10^{99}$. Numbers less than 10^{-99} are considered equal to 0.

You cannot enter numbers that exceed the limits of the display. When the display is full, the calculator ignores any additional digits.

Function Ranges

Numbers used as input must be within the range of the given function (under the usual definition of the function). The range for each of the calculator's functions is given in the following pages.

Function	Range
$\sin x$,	DEG: $\|x\| < 10^{10}$
$\cos x$,	RAD: $\|x\| < \frac{\pi}{180} \times 10^{10}$
$\tan x$,	GRAD: $\|x\| < \frac{10}{9} \times 10^{10}$
	With tan$x$, however, an error occurs in the following cases:
	DEG: $\|x\| = 90\,(2n - 1)$
	RAD: $\|x\| = \frac{\pi}{2}(2n-1)$
	GRAD: $\|x\| = 100\,(2n - 1)$ (n is an integer)

Function	Range
$\sin^{-1} x$, $\cos^{-1} x$	$-1 \leqq x \leqq 1$
$\tan^{-1} x$	$\|x\| < 10^{100}$
$\ln x$, $\log x$	$10^{-99} \leqq x < 10^{100}$
e^x	$-10^{100} < x \leqq 230.2585092$
10^x	$-10^{100} < x < 100$
y^x	$y > 0$: $-10^{100} < x \log y < 100$ $y = 0$: $0 < x < 10^{100}$ $y < 0$: $-10^{100} < x \log \|y\| < 100$ where x is an integer or $1/x$ is an oddnumber ($x \neq 0$)
$\sqrt[x]{y}$	$y > 0$: $-10^{100} < \frac{1}{x} \log y < 100$ ($x \neq 0$) $y = 0$: $0 < x < 10^{100}$ $y < 0$: $-10^{100} < \frac{1}{x} \log \|y\| < 100$ where x is an odd number or $1/x$ is an integer ($x \neq 0$)
$\sinh x$, $\cosh x$, $\tanh x$	$\|x\| \leqq 230.2585092$
$\sinh^{-1} x$	$\|x\| < 10^{50}$
$\cosh^{-1} x$	$1 \leqq x < 10^{50}$
$\tanh^{-1} x$	$\|x\| < 1$

Function	Range
$\sqrt{x}$	$0 \leqq x < 10^{100}$
$\sqrt[3]{x}$	$\lvert x \rvert < 10^{100}$
x^2	$\lvert x \rvert < 10^{50}$
x^{-1}	$\lvert x \rvert < 10^{100} (x \neq 0)$
n!	$0 \leqq n \leqq 69$ (n is an integer)
nPr	$0 \leqq r \leqq n \leqq 9999999999$ $\frac{n!}{(n-r)!} < 10^{100}$ (n, r are integers)
nCr	$0 \leqq r \leqq n \leqq 9999999999$ $0 \leqq r \leqq 69$ $r \leqq n$ $\frac{n!}{(n-r)!} < 10^{100}$ (n, r are integers)
→ DEG	$0^\circ\,00'\,00.01 \leqq \lvert x \rvert < 10000^\circ$ ($D^\circ\,M'\,S$ and sexagesimal calculations). If $\lvert x \rvert$ is less than $0^\circ\,00'\,00.01$, it is treated as zero in calculations.
$x,y \rightarrow r, \theta$	$\sqrt{x^2+y^2} < 10^{100}$
$r, \theta \rightarrow x,y$	$0 \leqq r < 10^{100}$ θ has the same restrictions as for trigonometric functions.

Function	Range
DRG ▶	DEG → RAD: $\lvert x \rvert < 10^{100}$ RAD → GRAD: $\lvert x \rvert > \frac{\pi}{2} \times 10^{98}$ GRAD → DEG: $\lvert x \rvert < 10^{100}$
Conversions → DEC, → BIN, → OCT, → HEX, AND, OR, XOR, XNOR	Converted result: DEC: $\lvert x \rvert \leqq 9999999999$ BIN: $1000000000 \leqq x \leqq 1111111111$ $0 \leqq x \leqq 111111111$ OCT: $4000000000 \leqq x \leqq 7777777777$ $0 \leqq x \leqq 3777777777$ HEX: FDABF41C01 $\leqq x \leqq$ FFFFFFFFFF $0 \leqq x \leqq$ 2540BE3FF
Bin/Oct/Hex number operations NOT	BIN: $1000000000 \leqq x \leqq 1111111111$ $0 \leqq x \leqq 111111111$ OCT: $4000000000 \leqq x \leqq 7777777777$ $0 \leqq x \leqq 3777777777$ HEX: FDABF41C01 $\leqq x \leqq$ FFFFFFFFFF $0 \leqq x \leqq$ 2540BE3FE
NEG	BIN: $1000000001 \leqq x \leqq 1111111111$ $0 \leqq x \leqq 111111111$ OCT: $4000000001 \leqq x \leqq 7777777777$ $0 \leqq x \leqq 3777777777$ HEX: FDABF41C01 $\leqq x \leqq$ FFFFFFFFFF $0 \leqq x \leqq$ 2540BE3FF
Others	The ranges for entries and results in each mode are as for "conversion" above.

Statistical Calculations: the absolute value of the final and intermediate results must be less than 10^{100}.

Intermediate Calculations

Some of the functions calculate intermediate results before the final answer is displayed. The intermediate calculations must stay within the same limits as the final results.

Error Conditions

Code	Error Conditions
Er1	· Syntax error Example: You attempt to perform coordinate conversion or two-variable statistics with only one data.
Er2	· The absolute value of a calculation is equal to or greater than 10^{100}. · A number is divided by zero. · A number used with a function exceeds the specified range for the function.
Er3	· The buffer for numbers (1~6 steps) or the buffer for operations (1~ 16 steps) overflows.

If any of the above errors occurs, the error indicator "Er1" through "Er3" appears in the left of the display.
Press the [ON/C] key to clear the error.

Appendix C:
Taking Care of Your Calculator

Care

To ensure trouble-free operation of your Sharp calculator, keep the following points in mind when using your calculator.

- Keep your calculator out of direct sunlight and away from high temperatures.
- Keep your calculator away from rapid temperature changes, moisture, and dust.
- Your calculator's display is made from a liquid crystal sealed between two glass plates. Avoid dropping or jarring the calculator, and do not carry it in your back pants pocket.
- Clean your calculator with a soft, dry cloth. Do not use water or solvents.
- Do not leave the batteries in your calculator if you will not be using in for an extended period.
- If your calculator needs service, use only an authorized Sharp Service Center.
- Keep this manual for reference.

Batteries

The calculator uses two alkaline-manganese batteries (model LR44) for power. If the indicators and numbers in the display appear dim, the batteries should be replaced as soon as possible.

HOW TO REPLACE THE BATTERY

1. Press the [2ndF] [OFF] key to turn off the calculator.
2. Remove the two screws holding the back cover of the calculator, and remove the back cover.
3. Remove the used batteries from the battery compartment by prying with a ball point pen or similar instrument.
4. Install two fresh batteries (model LR44 or equivalent) with their positive (+) sides facing out of the calculator.
5. Replace the back cover and secure it with the screws.
6. Press the RESET switch on the back.
7. Once the batteries have been replaced, check to see if "▲" points to "O:NOMAL"AND "DEG O." is displayed. If not, remove the batteries and install them again.

HINTS ON BATTERY USE

- Use only model LR44 (or equivalent) alkaline-manganese batteries.
- Replace both batteries at the same time. Do not mix new and used batteries.
- Be sure the batteries are installed with their positive terminals facing out of the calculator.

CAUTIONS

- Keep batteries out of reach of children.
- Dispose of the battery in a safe place. The battery may explode if disposed of in a fire.
- To avoid damage by corrosive leakage, remove the battery when it is worn out or when the calculator is to be stored for a long period of time.

Appendix D:
Specifications

Model:	EL – 506G
Display capacity	Floating-point display: 10 digits. Exponent display: Mantissa: 10 digits Exponent: 2 digits
	Calculations: 4 basic arithmetic calculations, constant calculations, memory calculations, decimal/sexagesimal conversions, sexagesimal calculations, trigonometric and inverse trigonometric functions, logarithmic functions, exponential functions, square and power functions, square root, cube root, power root, reciprocal, factorial, coordinates conversion, hyperbolic and inverse hyperbolic functions, precent, complex number calculations,binary/octal/hexadecimal calculations, logical operations, permutations, combinations, fractional operations, simultaneous linear equations with three unknowns, metric conversions, physical constants, statistical calculations.
Component:	LSI, etc.
Display type:	Liquid crystal (FEM type)
Power supply:	3V DC from 2 alkaline-manganese batteries (model LR44)
Power consumption:	0.0006W

Life of battery:	LR44: Approx.1300 hours while displaying 55555. at 20℃ (68° F) (The operating time can vary depending on the type of the battery or usage.) (Batteries are factory installed before shipment. They may require replacement in less than 1,300 hours.)
Operating temperature:	0℃ to 40℃ (32° F to 104° F)
Dimensions:	76 × 143 × 8.5mm ($3\times5\frac{5}{8}\times\frac{11}{32}$inch) (without hard case)
Weight:	70 g (0.15 lb) (with batteries)
Accessories:	Two LR44 alkaline-manganese batteries (installed), quick reference card, hard case, operation manual.

Appendix E:
Function Count

Mathematical Functions

Function Type	Functions	Count
Trigonometric	sin, cos, tan (for each angular unit)	9
Inverse Trigonometric	$\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, (for each angular unit)	9
Exponential & Logarithmic	e^x, 10^x, ln, log	4
Power, Root	y^x, $\sqrt[x]{y}$	2
Algebraic	x^2, $\sqrt{\ }$, $\sqrt[3]{\ }$, x^{-1}	4
Hyperbolic	sinh, cosh, tanh	3
Inverse Hyperbolic	$\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$	3
Angular Units	DEG, RAD, GRAD, angular unit conversions (DEG ↔ RAD, DEG ↔ GRAD, RAD ↔ GRAD)	9
Degree Conversions	→ D°M'S, → DEG	2
Coordinate Conversions	→ $r\theta$, → xy	2
Number Base Conversions	DEC ↔ BIN, DEC ↔ OCT DEC ↔ HEX, BIN ↔ OCT, BIN ↔ HEX, OCT ↔ HEX	12
Change Base Calculating	HEX, OCT, BIN, NEG (+/−).	4
Complex Number Calculations	+, −, ×, ÷, $r\theta \leftrightarrow xy$, parenthesized calculation, mixed calculation of xy and $r\theta$	8
Statistics:		
One-variable	n, Σx, Σx^2, $\bar{x}$, σx, sx	6
Two-variable	Σy, Σy^2, Σxy, $\bar{y}$, σy, sy	6

Function Type	Functions	count
Linear Regression	r, a, b, a, b, c (quadratic), r,a,b (exponential, power, logarithmic, inverse)	18
Estimation	x', y'	2
Others	CD, DATA	2
Modify	MDF	1
Factorial	n !	1
Permutations, Conbinations	nPr, nCr	2
Percent	%, + %, − %, × %, ÷ %	5
Random Number	RANDOM	1
Simultaneous Linear Equations	3-VLE, determinant	2
Sexagesimal Calculations	+, −, ×, ÷, constant calculation. STO, RCL, M + , M −	12
Logical Operations	NOT, AND, OR, XOR, XNOR	5
Fractional Operations	+, −, ×, ÷, fraction ↔ decimal, a b/c ↔ d/c, constant calculation, STO, RCL, M + , M −	16
Pending Operations	16 calculation instructions,6 numbers	22
Display Format	FIX, SCI, ENG, TAB (0–9)	13
Data Entry	π , Exp, 32 physical constants	34
Metric Conversions		32
Total Scientific Functions		251

Calculator Functions

Function Type	Functions	Count
Clear, Edit	C, CE, CA, →	4
Arithmetic	+, −, ×, ÷	4
Accumulator	STO, RCL, M + , M −	4
Constant memory	A, B, C, D, X, Y	6
Last Answer Memory	ANS	1
Negative Number Entry	+/−	1
Constant Calculation	+, −, ×, ÷, x + ? ↔ ? + x	5
Total Calculator Functions		25
Total Functions		276

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